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Dye-doped chiral nematic liquid crystal (LC) photonic band-edge lasers offer new disposable solutions for bespoke coherent light sources. Recent advancements include the gradient pitch LC laser *[1]*, whereby a spatial variation in chiral pitch length (and dye concentration) across the cell, enables continuous wavelength tuning of the laser through simple variation of the spatial location of the focussed pump beam. Pitch gradients are formed through the diffusion of 2 lasing mixtures, each optimised for a different emission wavelength. Unfortunately, perpetual diffusion limits the stability of the pitch gradient for only a few weeks/months, ultimately decaying to a uniform pitch with no wavelength tuning capability. Polymer stabilisation has been hypothesised as an appropriate technique to fix pitch gradients and prevent further diffusion. Unfortunately, previous experiments have found that lasing is often no longer possible after polymer stabilisation, or occurs with significantly reduced performance *[2]*. This has been attributed to poor UV stability of the organic laser dyes, but has not been studied extensively.

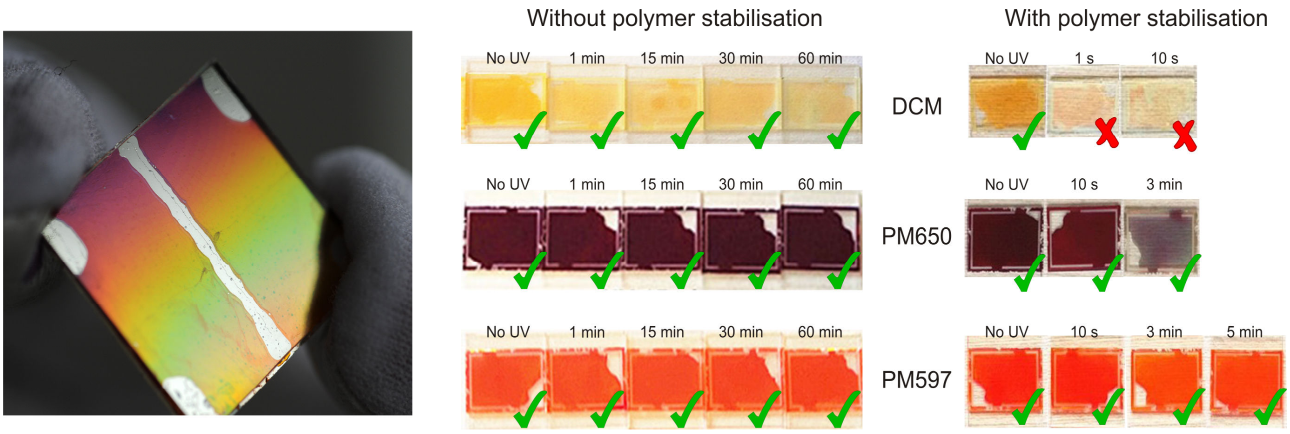

Fig 1. Gradient-pitch LC laser (left). Images of different dye-doped LC laser cells with increasing UV exposure (right), with and without polymer-stabilisation (2% RM257, 0.5% Irgacure 819). The ticks and crosses denote successful and unsuccessful lasing achieved respectively. (Note NMR experiments determined minimum time for complete polymerisation is 1 minute at 46 mW/cm^2).

This paper investigates the UV stability of a selection of organic dyes (DCM, PM597, PM597-8C9, PM650, Ph660) in LC lasers stabilised by the polymer RM257. We establish that UV damage is attributed to free-radical attack of the dye, caused by the presence of photoinitiator (Irgacure 819). Such damage reduces dye absorption/fluorescence capabilities and increases lasing thresholds. The effect is particularly pronounced in the popular dye DCM. However, alternative choices of dye (particularly pyrromethenes) were shown to be more resistant to such attack, beyond the timescales required for complete polymerisation of the sample (>1 min). This enables polymer stabilised gradient pitch LC laser systems to be successfully fabricated, with negligible effect upon laser performance. An additional note of discovery was that UV stability of LC lasers (containing no polymer) was far better than previously expected (exceeding 1 hour at 46 mW/cm^2). This result bodes well for the future applications and commercialisation of LC laser sources.

References

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2. J. Schmidtke, W. Stille, *et al.*, Advanced Materials, 14, 746 (2002)